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# (54) Piston dosing pump

(57) A pump for delivering accurately a measured quantity of a fluid e.g. or anaesthetic comprises a piston 11 in a cylinder 10, each of which is reciprocated by eccentric drives 16,17. Into pump space 9 there open the inlet valve 10,13 and outlet valve 6.

From the position immediately after discharge, with piston seal 14 abutting surface 30, the sequence is as follows:
—cylinder 10 is depressed to open valve 10,13,
—piston 11 is then retracted to draw in a measured dose of fluid,
—cylinder 10 then rises to close valve 10,13 and then,
—piston 10 goes through its discharge stroke.

The valve 10,13 is not as narrow as usual and so avoids throttling on the intake stroke with the consequences of vapour lock and incomplete filling of the pump chamber.

There may be, as is shown, a disc valve 4 after the ball valve 6.

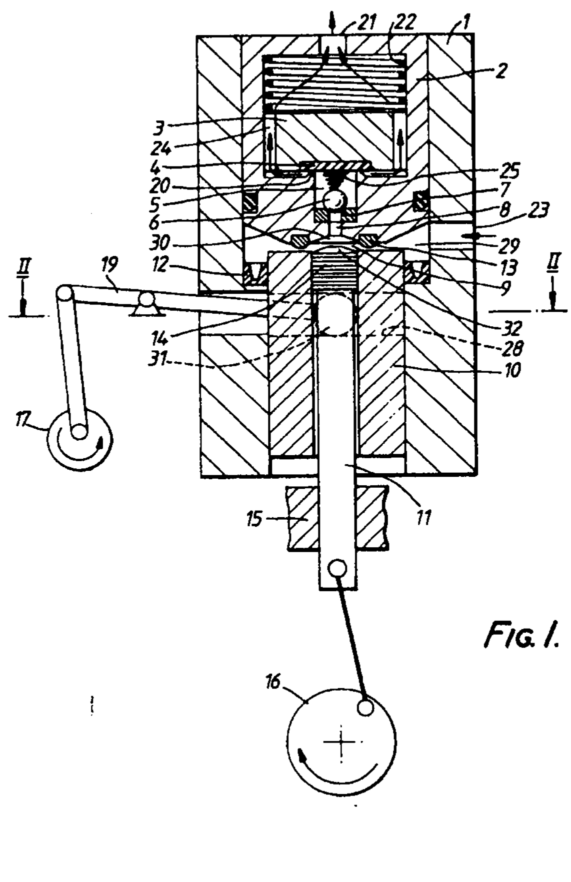


FIG. 1.

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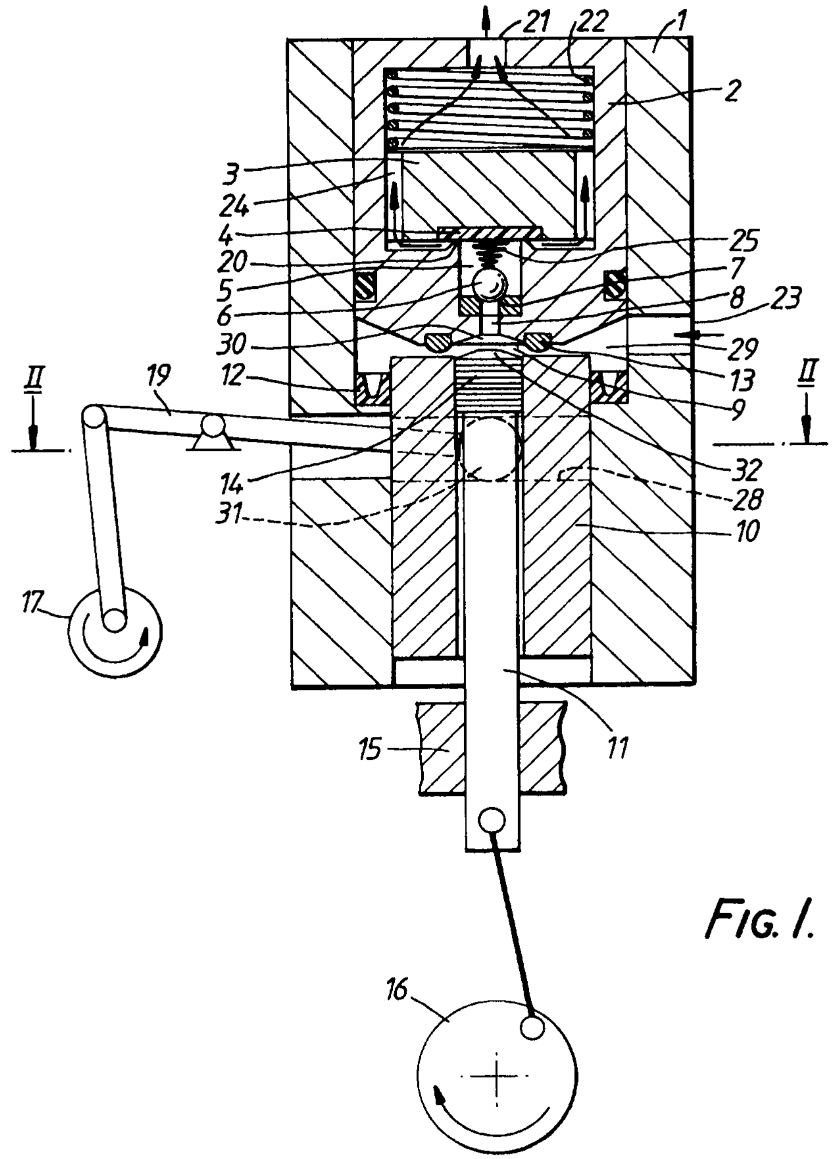


FIG. 1.

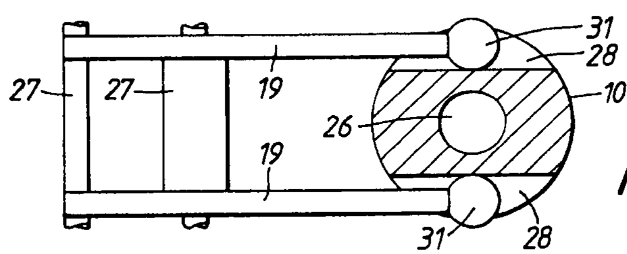


FIG. 2.

SPECIFICATION

**Piston dosing pump**

This invention relates to a dosing pump for a fluid comprising a piston in a cylinder, inlet and outlet valves and an oscillating drive.

One such piston dosing pump is described in DE-OS-33 31 558, and the corresponding British Patent Application, Publication No. 2145778A. It is used in order to be able to dose very small amounts of a liquid or gaseous medium exactly and reproducibly. The known dosing pump consists of a piston, which is guided in a cylinder, and which is caused by an oscillating drive, such as a crank mechanism, to execute periodic suction and pressure strokes. Into the pump space open both an inlet and an outlet valve.

The known dosing pumps have the disadvantage that, during the intake phase, when the inlet valve is open, a drop in pressure occurs, caused by the resistance to fluid flow of the usually narrow inlet valve. This drop in pressure may cause a vapour lock, when conveying liquids with a high vapour pressure, or may lead to an incomplete filling of the pump space when conveying gaseous media. Thus, it is not possible to achieve an exact dosing. Further, during the subsequent pressure stroke, if liquid is to be squeezed out of the pump space via the outlet valve, any vapour bubble which is formed may not burst.

The exact and reproducible dosing of amounts of liquid or gaseous media in the range of microlitres requires the smallest possible flexibility of the valves, so that the dosed volume can be completely conveyed into the outlet line. Furthermore, at both the inlet and the outlet valve, improved measures for the avoidance of leakages must be taken. With the known piston dosing pump, it is not possible, when excess pressure occurs in the supply line, to prevent opening of the inlet valve, and hence the flow of the medium to be dosed out via the pump space and the outlet valve directly into the supply line. In this case, dosing is no longer possible, and uncontrolled flow of the medium to the consumer side results.

The present invention seeks to avoid the disadvantages mentioned above, in such a way that, even when the pump space is filled quickly, the formation of vapour bubbles, or of a low pressure during the intake phase, is avoided, while the clearance volume of the piston dosing pump remains small enough that it is possible to guarantee that the required dose is expelled through the outlet valve, which is designed to be as loss-free as possible.

According to the present invention, there is provided a dosing pump for a fluid, the pump comprising:

a piston, connected to a first oscillating drive and slidably located within a cylinder;

an inlet valve, for restricting or permitting the flow of fluid out of or into a pump space;

an outlet valve, for restricting or permitting the flow of fluid out of the pump space; and

an outlet, opening from the pump space surrounded by a part of the inlet valve and leading from the pump space to the outlet valve.

The advantages of the invention arise largely because, during the intake stroke, the fluid which is dosed can flow through the inlet valve, which is of large cross-section, into the pump space with very low dynamic pressure losses. As a result, even during the intake of liquids with high vapour pressures, such as liquid anaesthetics, the formation of vapour bubbles is, to a large extent, avoided. Similarly, the intake of gaseous media takes place without significant pressure losses.

Since, at the end of the pressure stroke, practically no connection line parts lie between the inlet valve and the pump space, the clearance volume during the pressure phase is small. In the inlet phase, by contrast, the inlet valve forms an inlet zone of large cross-section, which surrounds the circumference of the pump space, so that the piston can execute a powerful intake stroke to fill the pump space. Before the pressure stroke begins, the inlet valve is closed.

Since the outlet opens into the pump space within the inlet valve, it is advantageous that the movable valve part of the inlet valve is formed by the cylinder in which the piston is guided. The cylinder is moved, by its own drive means, synchronously with the oscillating drive of the piston, such that, during the suction stroke, the inlet is connected to the pump space and such that, just before the beginning of the pressure stroke, the cylinder is pushed against a seal which surrounds the outlet, thus making possible the emptying of the pump space via the outlet. Alternatively, and equivalently, the cylinder might be fixedly mounted within the pump housing, with the valve housing being formed as a movable part of the inlet valve and controlled by the drive. However, such a design would result in a greater cost of the device because of the need to seal off the parts which can be moved relative to one another.

Advantageously, the movable valve part can itself also be formed by an annular seal, surrounding the outlet, which is curved forward by a control pressure into the valve space, in order to abut against its bearing surface. The controllable annular seal may be disposed, according to convenience, either on the piston side or on the outlet side. In one simply constructed form, it may consist of an annular membrane located in an annular groove, the control pressure line being connected to the annular groove. The pressure production takes place in the same synchronisation, matched to

the piston movement, as was described for the movable cylinder. The pressure-producing medium can be either liquid or gaseous.

With the moved cylinder in motion, the rest of the stroke, from the closing of the seal up to a positive stop of the cylinder, goes into the dosing amount as an additional stroke. By analogy, a similar thing happens when the cylinder is at rest and the annular membrane is expandable. In order to cut out this additional stroke, the combination of a movable cylinder and a controllable annular seal can be provided, the operation of the annular seal not following until the cylinder has come to rest at the positive stop.

In a particularly advantageous embodiment of the invention, the cylinder is guided coaxially with the piston, and the cylinder drive is provided via a flexible length compensating part. For a firm and definite closing off the pump space by the inlet valve, the cylinder is forced against the annular seal until it stops against the surface surrounding the annular seal, so that a piston seal, provided with a convex front end, can be forced into the correspondingly concave surface of the outlet, at the end of the pressure stroke, in order thus to be able to empty the pump space completely. Thereby, at the same time, any gas bubbles present are squeezed out of the pump space too. In order to ensure a firm stop to the cylinder stroke, even with different length tolerances of the cylinder and of the drive mechanism, the flexible length compensating part compensates for these tolerances.

The outlet valve consists of a ball valve to which a prestressed disc valve, downstream thereof, is connected. The ball valve closes off the clearance space volume, formed by the outlet, towards the disc valve, causes the required dose, located in the pump space, to be exactly and reproducibly conveyed and ensures that the pump space is only very slightly flexible. The valve chamber of the ball valve is closed off in the downstream direction by the prestressed disc valve. Any flexibility of the flat seal of the disc valve will, because of the presence of the ball valve, have no effect on the clearance space. Should the disc valve not seal completely, the ball valve ensures that any liquid, located in the conveying line behind the disc valve when the inlet valve is open, is prevented from running backwards. If the disc valve should seal completely, but the ball valve incompletely, then only the volume located between the two would flow back. The disc valve opens only if the dose conveyed by the pressure stroke of the piston overcomes its closing pressure. If, as a result of an error, an undesirably high pressure should build up in the supply line to the inlet valve, as can occur, for example, with insufficient aeration or heating of the store tank, then the closing pressure of the disc valve is chosen such that, with the inlet valve opened, uncontrolled penetration of the medium through the dosing pump cannot follow. The provision of a matched convex piston front end and concave run-in surface permits any vapour bubbles, insofar as these should get into the pump space, to be squeezed out. This can result, for example, if the storage tank for a liquid medium is pumped empty and only air is taken in.

The material zirconium oxide ceramics has proved particularly favourable for use in the manufacture of the cylinder, since it has better friction qualities between the cylinder head seal and the running surface of the cylinder, as well as the necessary outer seals, than is the case with otherwise similarly suitable materials, such as hard metal, sapphire, aluminium oxide ceramics or amorphous glass graphite.

For a better understanding of the present invention, and to show how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows, in section, a piston dosing pump according to one embodiment of the invention; and

Figure 2 is a view, along the line II-II, of a length compensating element which may form part of a dosing pump according to this invention.

The piston dosing pump shown in Figure 1 includes a pump housing 1, containing a valve housing 2 and a movable cylinder 10. The valve housing 2 contains a disc valve 3, 20 and a ball valve 6, 7. A piston 11 is disposed inside, and displaceably relative to, the cylinder 10. An inlet 23 of the pump housing 1 opens into an inlet chamber 29. Adjacent a pump space 9, the valve housing 2 has a concave surface 30 for an outlet 8. This outlet is sealed by a ball 6 pressed on its seat 7 by a ball spring 25. The valve space 5 of the ball valve 6, 7 is covered by a flat seal 4 in the disc valve 3, 20 along the seal crater 20. The disc valve 3, 20 is held by the pressure spring 22 and is provided with guide ribs 24, between which are formed outlet channels.

A piston drive 16 is in the form of a crank mechanism, and forces the piston 11 to execute oscillating suction and pressure strokes along the inner surface of the cylinder 10, against which it is sealed by the piston seal 14 on its end. This may, for example for the conveying of liquid anaesthetics, be formed of polytetrafluorethylene (PTFE). The dome-shaped piston seal 14 is fixed in place by a rib, located on its inside, slotted into a groove formed in the piston 11. On its outer side, the piston seal has piston-ring-shaped sealing lips, which are brought into contact with the cylinder 10 by spring elements arranged between the piston 11 and piston seal 14. The piston seal 14 has, at its forward end 32, a convex shape adapted to co-operate with the concave

surface 30. Guidance of the piston is controlled by the piston bearing 15.

The cylinder 10 is guided movably in the pump housing 1, by its own cylinder drive 17 and the rocker 19, co-axially with the piston 11. The cylinder 10 thus forms the movable valve part for the inlet valve 10, 13. The sealing off of the cylinder 10 against the pump housing 1 is controlled by a lip seal 12, formed of PTFE, the cross-section of which is of a generally U-shape. A spring element is let into the U-shaped recess in the lip seal 12, and forces the two lips against the surfaces which are to be sealed off. The piston dosing pump shown in Figure 1 operates as is described below.

In Figure 1, the piston dosing pump is shown in the position in which the medium in the pump space 9 has been forced out by the piston 11 through the outlet 8. Subsequently, the cylinder 10 has been lifted from its stop against the annular seal 13 by the cylinder drive 17, and thus the inlet valve 10, 13 has been opened. Now, during one half revolution of the piston drive 16, the piston 11 executes a full suction stroke, whereby the medium to be dosed, for example a liquid anaesthetic, is drawn into the expanding pump space 9 via the inlet 23.

At the end of the suction stroke, the cylinder 10 is forced against the annular seal 13 until the forepart of the cylinder 10 abuts against the surface of the valve housing 2 which faces it. The inlet valve 10, 13 is thus closed, and the pressure stroke of the piston 11 can begin. According to the operational requirements and depending upon the orientation of the piston drive 16, the contents of the pump space 9 can be forced out, via the outlet 8, ball valve 6, 7 and disc valve 3, 20 through the opening 21 to the consumer without interruption in one full pressure stroke or in a series of partial steps. When the top dead centre of the pressure stroke is reached, the forward end of the piston seal 14 abuts against the surface 30. Thus, a complete pump cycle is concluded.

In Figure 2, there is shown an exemplary embodiment of the length compensating element 19, which imparts the oscillating motion to the cylinder 10. The cylinder 10 has a cylindrical bore hole 26, and two slots 28 transverse to its longitudinal axis. The ball-shaped ends 31 of the rocker, which is formed out of two rods 19, are guided slidably within these slots. The two rods 19 are connected together at the joints of the rocker by rods 27. At the end of each cylinder stroke, the cylinder 10 abuts firmly against the front part of the valve housing 2. Further motion of the driven end of the rocker 19 imparted by the cylinder drive 17 merely results in elastic bending of the rocker 19.

## CLAIMS

1. A dosing pump for a fluid, the pump comprising:
a piston, connected to a first oscillating drive and slidably located within a cylinder;
an inlet valve, for restricting or permitting the flow of fluid out of or into a pump space;
an outlet valve, for restricting or permitting the flow of fluid out of the pump space; and
an outlet, opening from the pump space surrounded by a part of the inlet valve and leading from the pump space to the outlet valve.

2. A dosing pump as claimed in claim 1, wherein a movable part of the inlet valve comprises an annular seal surrounding the outlet, which can be moved in the direction of the valve surface by an actuating pressure.

3. A dosing pump as claimed in claim 1, wherein the cylinder is connected to a second oscillating drive and forms a movable part of the inlet valve.

4. A dosing pump as claimed in claim 3, in which the cylinder is guided coaxially with the piston, and the cylinder drive is provided with a flexible length compensating section.

5. A dosing pump as claimed in claim 3 or 4, wherein the cylinder is formed of zirconium oxide ceramics.

6. A dosing pump as claimed in any preceding claim, wherein the outlet valve comprises a ball valve and a prestressed disc valve connected thereto.

7. A dosing pump as claimed in any preceding claim, wherein that end region of the piston which is nearer the pump space has a convex shape, and the outlet is surrounded by a corresponding concave mating surface.

8. A dosing pump, substantially as herein described with reference to, or as shown in, Figure 1 or Figures 1 and 2 of the accompanying drawings.

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